measure hydrocarbon, nitrogen oxide, methanol, formaldehyde and particulate depend on the type of engine being tested; petroleum-fueled diesel engines require a heated, continuous hydrocarbon detector and a heated, continuous nitrogen oxide detector (see § 86.1310); methanol-fueled engines require a heated hydrocarbon detector, a methanol detector and a formaldehyde detector; either a heated or non-heated continuous hydrocarbon detector may be used with natural gas-fueled and liquefied petroleum gas-fueled diesel engines; gasoline-fueled, natural gas-fueled, liquefied petroleum gas-fueled and methanol-fueled Otto-cycle engines are not tested for particulate emissions (see § 86.1309). Second, if a gasoline-fueled and methanol-fueled engine is to be used in a vehicle equipped with an evaporative canister, the test engine must have a loaded evaporative canister attached for the exhaust emission test. Necessary equipment and specifications appear in §§ 86.1308, 86.1309, 86.1310 and 86.1311.

(b) *Fuel, analytical gas, and engine cycle specifications.* Fuel specifications for exhaust emission testing are specified in § 86.1313. Analytical gases are specified in § 86.1314. The EPA heavy-duty transient engine cycles for use in exhaust testing are described in § 86.1333 and specified in appendix I to this part.

[58 FR 16064, Mar. 24, 1993, as amended at 59 FR 48525, Sept. 21, 1994]

§ 86.1308–84 Dynamometer and engine equipment specifications.

(a) *Engine dynamometer.* The engine dynamometer system must be capable of controlling engine torque and rpm simultaneously over transient cycles. The transient torque and rpm schedules described in § 86.1333–84 and specified in appendix I ((f)(i), (2), and (3)) must be followed within the accuracy requirements specified in § 86.1341–84. In addition to these general requirements, the engine or dynamometer readout signals for speed and torque shall meet the following accuracy specifications:

(1) Engine speed readout shall be accurate to within ±2 percent of the absolute standard value, as defined in paragraph (d) of this section.

(2) Engine flywheel torque readout shall be accurate to either within ±3 percent of the NBS ''true'' value torque (as defined in paragraph (e) of this section), or the following accuracies:

(i) ±2.5 ft-lbs. of the NBS ''true'' value if the full scale value is 550 ft-lbs. or less.

(ii) ±5 ft-lbs. of the NBS ''true'' value if the full scale value is 1050 ft-lbs. or less.

(iii) ±10 ft.-lbs., of the NBS ''true'' value if the full scale value is greater than 1050 ft.-lbs.

(3) *Option:* Internal dynamometer signals (i.e., armature current, etc.) may be used for torque measurement provided that it can be shown that the engine flywheel torque during the test cycle conforms to the accuracy specifications in paragraph (a) of this section. Such a measurement system must include compensation for increased or decreased flywheel torque due to the armature inertia during accelerations and decelerations in the test cycle.

(b) *Cycle verification equipment.* In order to verify that the test engine has followed the test cycle correctly, the dynamometer or engine readout signals for speed and torque must be collected in a manner that allows a statistical correlation between the actual engine performance and the test cycle (See § 86.1341–84). Normally this collection process would involve conversion of analog dynamometer or engine signals into digital values for storage in a computer. The conversion of dynamometer or engine values (computer or other) that are used to evaluate the validity of engine performance in relation to the test cycle shall be performed in a manner such that:

(1) Speed values used for cycle evaluation are accurate to within 2 percent of the dynamometer or engine flywheel torque readout value.

(2) Engine flywheel torque values used for cycle evaluation are accurate to within 2 percent of the dynamometer or engine flywheel torque readout value.

(c) *Option:* For some systems it may be more convenient to combine the tolerances in paragraphs (a) and (b) of this section. This is permitted if the root mean square method (RMS) is used.

The RMS values would then refer to accuracy in relationship to absolute standard or to NBS ''true'' values.

(1) Speed values used for cycle evaluation shall be accurate to within ±2.8 percent of the absolute standard values, as defined in paragraph (d) of this section.

(2) Engine flywheel torque values used for cycle evaluation shall be accurate to within ±3.6 percent of NBS ''true'' values, as determined in paragraph (e) of this section.

(d) *Speed calibration equipment.* A 60-tooth (or greater) wheel in combination with a common mode rejection frequency counter is considered an absolute standard for engine or dynamometer speed.

(e) *Torque calibration equipment.* Two techniques are allowed for torque calibration. Alternate techniques may be used if shown to yield equivalent accuracies. The NBS ''true'' value torque is defined as the torque calculated by taking the product of an NBS traceable weight or force and a sufficiently accurate horizontal lever arm distance, corrected for the hanging torque of the lever arm.

(1) The lever-arm dead-weight technique involves the placement of known weights at a known horizontal distance from the center of rotation of the torque measuring device. The equipment required is:

(i) *Calibration weights.* A minimum of six calibration weights for each range of torque measuring device used are required. The weights must be approximately equally spaced and each must be traceable to NBS weights. Laboratories located in foreign countries may certify calibration weights to local government bureau standards. Certification of weight by state government Bureau of Weights and Measures is acceptable. Effects of changes in gravitational constant at the test site may be accounted for if desired.

(ii) *Lever arm.* A lever arm with a minimum length of 24 inches is required. The horizontal distance from the centerline of the engine torque measurement device to the point of weight application shall be accurate to within ±0.10 inches. The arm must be balanced, or the hanging torque of the arm must be known to within ±0.1 ft-lbs.

(2) The transfer technique involves the calibration of a master load cell (i.e., dynamometer case load cell). This calibration can be done with known calibration weights at known horizontal distances, or by using a hydraulically actuated precalibrated master load cell. This calibration is then transferred to the flywheel torque measuring device. The technique involves the following steps:

(i) A master load cell shall be either precalibrated or be calibrated per paragraph (e)(1)(i) of this section with known weights traceable to NBS, and used with the lever arm(s) specified in paragraph (e)(2)(ii) of this section. The dynamometer should be either running or vibrated during this calibration to minimize static hysteresis.

(ii) A lever arm(s) with a minimum length of 24 inches is (are) required. The horizontal distances from the centerline of the master load cell, to the centerline of the dynamometer, and to the point of weight or force application shall be accurate to within ±0.10 inches. The arm(s) must be balanced or the net hanging torque of the arm(s) must be known to within ±0.1 ft.-lbs.

(iii) Transfer of calibration from the case or master load cell to the flywheel torque measuring device shall be performed with the dynamometer operating at a constant speed. The flywheel torque measurement device readout shall be calibrated to the master load cell torque readout at a minimum of six loads approximately equally spaced across the full useful ranges of both measurement devices. (Note that good engineering practice requires that both devices have approximately equal useful ranges of torque measurement.) The transfer calibration shall be performed in a manner such that the accuracy requirements of paragraph (a)(2) of this section for the flywheel torque measurement device readout be met or exceeded.

(3) Other techniques may be used if shown to yield equivalent accuracy.

(f) *Diesel engines only.* If direct measurement of mass fuel consumption is chosen as an option in lieu of dilute exhaust CO_2 measurement, the fuel measurement device shall be accurate to within ±2 percent of actual mass fuel flow.

[48 FR 52210, Nov. 16, 1983, as amended at 49 FR 48142, Dec. 10, 1984; 52 FR 47870, Dec. 16, 1987]

§ 86.1309–90 Exhaust gas sampling system; Otto-cycle and non-petroleum-fueled engines.

(a)(1) *General.* The exhaust gas sampling system described in this paragraph is designed to measure the true mass of gaseous emissions in the exhaust of either gasoline-fueled, natural gas-fueled, liquefied petroleum gas-fueled or methanol-fueled engines. In the CVS concept of measuring mass emissions, two conditions must be satisfied; the total volume of the mixture of exhaust and dilution air must be measured, and a continuously proportioned volume of sample must be collected for analysis. Mass emissions are determined from the sample concentration and total flow over the test period.

(2) *Engine exhaust to CVS duct.* For methanol-fueled engines, reactions of the exhaust gases in the exhaust duct connected to the dilution tunnel (for the purposes of this paragraph, the exhaust duct excludes the length of pipe representative of the vehicle exhaust pipe) shall be minimized. This may be accomplished by:

(i) Using a duct of unrestricted length maintained at a temperature below 599 °F (315 °C). (Cooling capabilities as required); or

(ii) Using a smooth wall duct less than five feet long with no required heating (a maximum of two short flexible connectors are allowed under this option); or

(iii) Omitting the duct and performing the exhaust gas dilution function at the engine exhaust manifold, immediately after exhaust aftertreatment systems, or after a length of pipe representative of the vehicle exhaust pipe; or

(iv) Partial dilution of the exhaust gas prior to entering the dilution tunnel, which lowers the duct temperature below 599 °F (315 °C).

(3) *Positive displacement pump.* The Positive Displacement Pump Constant Volume Sampler (PDP-CVS), Figure N90–1 satisfies the first condition by metering at a constant temperature and pressure through the pump. The total volume is measured by counting the revolutions made by the calibrated positive displacement pump. The proportional samples for the bag sample, the methanol sample (Figure N90–2), and the formaldehyde sample (Figure N90–3), as applicable are achieved by sampling at a constant flow rate. For methanol-fueled engines, the sample lines for the methanol and formaldehyde samples are heated to prevent condensation. (Note: For 1990 through 1994 model year methanol-fueled engines, methanol and formaldehyde sampling may be omitted provided the bag sample (hydrocarbons and methanol) is analyzed using a HFID calibrated with methanol.)